

A purple logging truck is shown from a low angle, heavily loaded with large, rough-barked logs. The truck's black metal frame and hydraulic crane are visible. It is parked on a dirt road in a forest setting. The text 'CHAPTER 12 Forest Road Construction and Maintenance' is overlaid on the bottom right of the image.

CHAPTER 12

Forest Road Construction and Maintenance

CHAPTER 12

FOREST ROAD CONSTRUCTION AND MAINTENANCE

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Roads, skid trails and landings comprise a forest transportation system. Skid trails are used to get forest products from the woods to a landing. A landing is used to stockpile timber for loading onto logging trucks. Forest roads connect the landings to existing public roads. Forest roads can also provide access needed for improving fish and wildlife habitat, fighting fires, and providing recreation. This chapter focuses on forest roads. Timber harvesting, skid trails, and landings are discussed in Chapter 13.

There are three types of forest roads: temporary, permanent seasonal, and permanent all-season. During the planning stage, identify the type of road system that is needed to meet both forest management and landowner objectives.

Temporary roads are the most common type of forest road. They are designed and constructed for short-term use during a specific project, like a timber harvest. These roads are used only when the ground is frozen or firm. When the project is done, the temporary road is closed, all stream crossing structures removed, and the road revegetated.

Permanent seasonal roads are maintained as part of the permanent road system, but are designed to be used only when the ground is frozen or firm. These roads are generally narrower than all-season forest roads and are built to lower engineering standards. Seasonal road will generally have little to no surface gravel.



Figure 12-1: Seeding can be as easy as spreading grass seed by hand as this landowner is doing on his freshly-graded woods road. Use non-invasive species and certified weed-free seed.

Permanent all-season forest roads are designed for year-round use, but may have use restrictions at various times of the year, such as spring break-up. These roads are built to higher standards than the others and usually have gravel surfaces. All-season roads can be the most expensive to build and maintain.

Integrated Resource Management Considerations

Well-planned and well-built forest roads make sense both economically and environmentally. The largest contributor to nonpoint source pollution from forest management activities is forest roads that are poorly located, constructed and maintained. Roads over steep slopes, erosion prone sites, streams, and wetlands hold the greatest potential for degrading water quality. Road construction may alter the flow of water over and through the ground. Heavy road use may expose soil, making it vulnerable to erosion. Stream crossings can change the hydrology of streams. All of these factors pose risks to waterbodies; however, water quality impacts can be avoided by properly designing, constructing and maintaining forest roads. Following the Forestry BMPs for Water Quality (WQ-BMPs) for forest roads can:

- Extend the road's season of use
- Reduce road wear and maintenance costs
- Enable trucks to haul heavier loads
- Lower truck maintenance costs
- Reduce travel time, and
- Protect water quality before, during and after timber harvests

Forest roads also provide an opportunity for non-native invasive species to move into areas, either on equipment constructing or maintaining the road, or on vehicles or footwear of road users. Servicing as many acres of forest with as few roads as possible is a sound method of reducing impacts of roads on forest resources.

FACTORS IN DECISION-MAKING

- The number, size and design of forest access roads will be influenced by the frequency of access, amount of anticipated traffic, seasons during which access is required, and safety concerns.
- Distribution of necessary management activities will affect the number and location of access roads.
- Choices regarding road construction standards and maintenance activities will be influenced by site characteristics, and the value of the resources served. Culverts and ditches may be necessary with any road construction technique.
- Access roads may act as a means for spreading non-native invasive plants, whether by human activity or wildlife (see 📄 5.1 and 📄 5.2).
- Surfacing can be the major cost of low-volume road construction. Alternatives should be evaluated according to expected use and potential impact on sediment load. Where grades make the potential for surface erosion significant, the road should be surfaced with materials such as crushed rock, compacted gravel, sod, or asphalt that will minimize potential water quality and soil productivity impacts (see 📄 5.5).

MINIMIZING THE IMPACTS OF ROADS

- Visual impacts and excessive noise can result from poor design, construction and maintenance of forest access roads. Take into account the following considerations when planning to reduce noise and visual impacts associated with the design and use of forest access roads:
 - Noise from traffic, especially large trucks, buses and heavy equipment.
 - Potential increased costs of building forest access roads to accommodate visual quality concerns, and potential increased costs of using existing roads that require traveling greater distances.
 - The limited road construction season that generally coincides with the tourist season.
 - Traffic during wet periods that can increase maintenance needs, and create unsightly ruts and mudholes.

- Visual impacts and noise impacts created by gravel pits are not compatible with recreational user sensitivities. Take into account the following considerations when planning to reduce noise and unsightliness related to gravel pits:
 - Local sources of gravel are necessary for efficient, cost-effective road building and maintenance.
 - Recreational use of gravel pits may cause conflicts.
- Site-specific soil, topographic and forest inventory information (including invasive species) will assist resource managers or landowners in planning road location and layout. For more information, see the Resource Directory.
- Because roads take soils out of production, effort should be made to keep the length and width of roads to a minimum without sacrificing safety.
- To minimize road mileage and reduce costs, coordination with adjacent landowners may be desirable.
- The greatest potential for soil erosion occurs immediately after construction. Disturbed areas should be shaped and stabilized as soon as possible to minimize erosion potential (see 📄 5.4).

MAINTENANCE NEEDS

- The purpose of maintenance procedures is to ensure measures taken to minimize impacts on forest resources are working, and continue to work into the future. Surfacing materials and the amount of use determine the level of maintenance required.
- Roads that are open for use require more maintenance than roads that are closed to vehicular traffic. Inactive roads (roads currently not in use) whether closed temporarily or permanently, require occasional work to reduce potential impacts on streams, lakes, wetlands, and seasonal ponds.
- Road layout, construction methods, and access control all contribute to the longevity, utility, safety, and maintenance cost of roads.
- Monitor for non-native invasive species, control their spread, and eradicate them if possible. Clean equipment as needed (see 📄 4.3 and 📄 4.4).

REDUCING VISUAL IMPACTS OF ROAD CLEARINGS

- Utilize merchantable timber within road clearings.
- Burn, screen or bury road-clearing debris such as stumps, rocks and boulders, so it is not visible from travel routes or recreation areas.
- Move cleared debris outside of the travel route right-of-way so it is minimally apparent.
- Avoid creating a corridor of debris.
- Do not leave jackstrawed or overturned stumps in the immediate foreground.
- Reduce the height of dozed clearing debris during road construction.

REDUCING VISUAL IMPACTS DUE TO ALIGNMENT AND LOCATION OF ROADS

- Minimize the number of roads approaching travel routes or recreation areas.
- Locate roads and trails to minimize visibility from nearby vantage points such as scenic overlooks, streams and lakes.
- Minimize total road mileage and ground disturbance required to meet landowner objectives and anticipated traffic loads.
- Avoid tracking mud onto highways by using appropriate road surface material.
- Reduce visual penetration with appropriate curves in road alignment.

REDUCING NOISE AND VISUAL IMPACTS OF GRAVEL PITS AND BORROW AREAS

- Locate borrow pits and crushing operations out of the visible corridor as much as possible.
- Screen pits from travel routes or recreation areas using existing vegetation or landscape berms.
- Rehabilitate pits upon completion of use.
- Reduce noise in early morning, late evening and other appropriate times whenever possible.
- Develop gravel or borrow pits from the back to the front of pits (moving toward the predominant view or vantage point).



Figure 12-2: Road maintenance activities spread garden forget-me-not along this access road. If it were identified prior to grading, it could have been avoided or controlled to minimize its spread.

PROTECTING WATER QUALITY AND WATER FLOW

- Following WQ-BMPs when designing, constructing and maintaining roads can minimize the potential impact of roads on water quality in lakes, streams and wetlands, as well as minimize alterations to normal water flow patterns.
- Effective road construction techniques minimize the disturbance to the natural flow of water over the landscape, and ensure the structural integrity of the road embankment.

The goals are to provide a simple road structure of adequate strength to support heavy vehicle traffic, and provide drainage structures to pass water at its normal level through the road corridor.

UPLAND FOREST ROADS

BMPs: Planning, Location and Design

Decisions made at the planning stage will affect a road's construction costs, long-term maintenance needs, service life, and the amount of nonpoint source pollution it causes. Loggers and landowners should plan, locate and design the road system together.

- ◆ Plan road systems that minimize the number, width and length of roads to limit the total area of the site disturbed. Remember to:
 - Consider future uses of the road system.
 - Coordinate development with adjoining landowners when possible.
 - Use temporary roads where practical.
- ◆ Use existing roads when they provide the best long-term access. Consider relocating existing roads if access can be improved and environmental impacts lessened. Reconstruct existing roads to the extent necessary to provide adequate drainage and safety. Do not disturb stable road surfaces.
- ◆ Select road locations that allow for drainage away from the road.
- ◆ Where possible, locate roads on well-drained soils.
- ◆ Minimize the number of stream, dry wash, and wetland crossings.
- ◆ Locate roads outside riparian management zones and wetland filter strips except at crossings. For more information, see Chapter 5: Riparian Areas and Wetlands.
- ◆ Road grades should not exceed 10 percent. If road grades greater than 10 percent are necessary, limit grade length to minimize erosion, or break the grade using drainage structures. Graveling the road surface on steep grades can also help to maintain stability. NOTE: Optimum roads grades should be less than five percent (see Figure 12-3).

- ◆ Locate roads to follow natural contours and to minimize cut and fills. Balance cut and fills to minimize the need for fill and removing excess fill material (see Figure 12-4).

5.2 Avoid constructing new roads, skid trails, and landings in areas infested with invasive species where possible.

5.3 Avoid spreading seeds and other propagules from infested to non-infested areas during road maintenance, reconstruction, new construction, and closure.

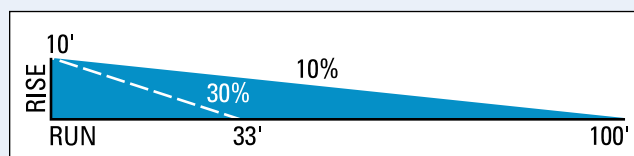


Figure 12-3: Road Grade % = Rise ÷ Run x 100

(Figure Credit: WDNR)

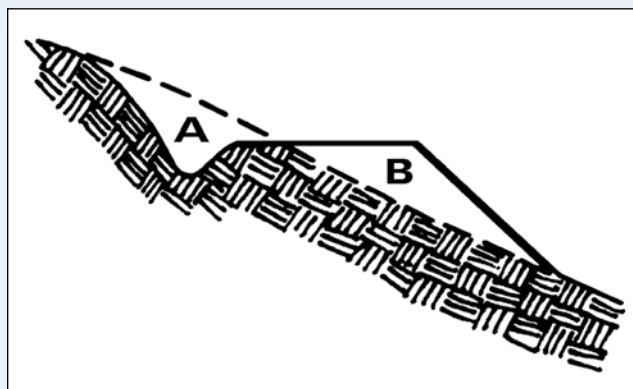


Figure 12-4: A side-hill cross-section illustrating how cut materials (A) equals fill materials (B).

(Figure Credit: WDNR)

STREAM CROSSING DESIGN AND CONSTRUCTION

Many stream crossings, especially culverts, can significantly affect streams if WQ-BMPs are not used to minimize impacts with proper design, installation and maintenance. Poorly designed, installed or maintained, crossings can change the physical characteristics of a stream – its speed, depth, and channel shape. Crossings can also create barriers for fish and other organisms trying to move upstream.

When planning a stream crossing, first determine whether there are other ways to access the parcel that would not require a new crossing. If the crossing is required, you will need to consider:

- the stream channel
- the stream banks
- the approaches to the crossing

The ideal location for a stream crossing is where the stream is straight and narrow with low banks and firm rocky soil. The road should approach the stream at the least gradient possible.

Factors in properly sizing a crossing include storm frequency, drainage area, and flow rates. Permit standards for crossings include information on how to size crossings. A properly sized crossing will not reduce fish passage problems, but will also reduce the likelihood of high water levels undermining or washing out the crossing. Washouts can also be avoided by provided a high water release as part of the approach. This high water release can be a dry culvert or dip in the approach.

Depending on the intensity of use, a temporary or permanent stream crossing may be more appropriate. Common temporary stream crossing designs used in forest management include portable bridges, timber mats and pole fords. For permanent crossings, bridges, culverts, and fords are often used.

The USDA Natural Resources Conservation Service, your local land conservation department, or a private consultant can assist with ford and culvert designs. To design a bridge, contact a private consultant or experienced contractor.



Figure 12-5: This stream crossing is undersized and perched, preventing fish movement upstream.



Figure 12-6: Timber mats provide an easy and cost-effective option for temporary stream crossings.

BMPs: Stream Crossings

The following WQ-BMPs provide general guidance on the design, installation, and maintenance of stream crossings. Permit requirements will include more detailed information on sizing and installing stream crossings. Be sure to refer to and understand permit requirements.

- ◆ Identify optimal stream crossing locations. Optimum locations are where the stream channel is straight and narrow with low banks and firm rocky soil. Roads should approach streams at the least gradient possible.
- ◆ Install stream crossing structures at right angles to the stream channel, where practicable.
- ◆ Use soil stabilization practices on exposed soil at stream crossings. Use seed and mulch, and install temporary sediment control structures immediately following construction to minimize erosion into streams. Maintain these practices until the soil is permanently stabilized (see Soil Stabilization, page 12-16).
- ◆ Design, construct and maintain stream crossings to avoid disrupting the migration or movement of fish and other aquatic life. Consider clear-span bridges, bottomless arch culverts and temporary stream crossings that retain the natural streambed.
- ◆ Install stream crossings using materials that are clean, non-erodible and non-toxic to aquatic life.
- ◆ Minimize channel changes and the amount of excavation or fill needed at the crossing.
- ◆ Limit construction activity in the streambed to periods of low or no flow. Keep use of equipment in the stream to a minimum.

- ◆ Use diversion ditches, broad-based dips or other practices on the road approach to prevent road runoff from entering the stream. Direct the runoff into undisturbed vegetation, preferably outside the riparian management zone (RMZ) (see Figures 12-7 and 12-8).

- ◆ Stabilize approaches to crossings with aggregate or other suitable material to reduce sediment entering the stream.



Figure 12-7: Use of fill when placing a culvert.
(Figure Credit: WDNR)



Figure 12-8: Example of a diversion ditch.
(WDNR, Jeff Martin)

BMPs: Culverts for Stream Crossings

- ◆ Install culverts that extend at least one foot beyond the road fill.
- ◆ Install culverts that are large enough to pass flood flows. To avoid plugging, wash-outs, and upstream flooding, culvert should be a minimum of 18 inches in diameter.
- ◆ Install culverts so there is no change in the streambed elevation. Culverts should not cause dam or pool water (see Figure 12-11).
- ◆ Firmly compact material around culverts, particularly the bottom half. To prevent crushing, cover the top of culverts with fill to a depth of one-third of the culvert diameter or at least 12 inches, whichever is greater (see Figure 12-9).
- ◆ Use riprap around the inlet and outlet of culverts to prevent water from eroding and undercutting the culverts. Use filter fabric or a filter layer of gravel under the riprap (see Figure 12-10). Consider using flared-end culvert sections.
- ◆ Keep culverts clear and free of debris so that water can pass unimpeded at all times. This is especially important in areas where beaver are present. Consider using a bevel cut culvert to facilitate debris removal. A bevel cut requires a longer culvert than a flat cut.

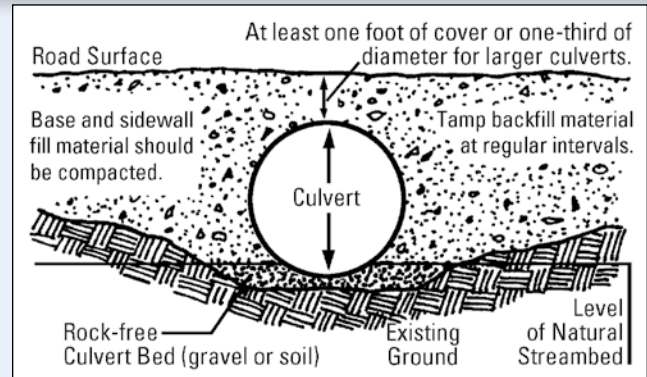


Figure 12-9: Installation of culverts. (Figure Credit: WDNR)

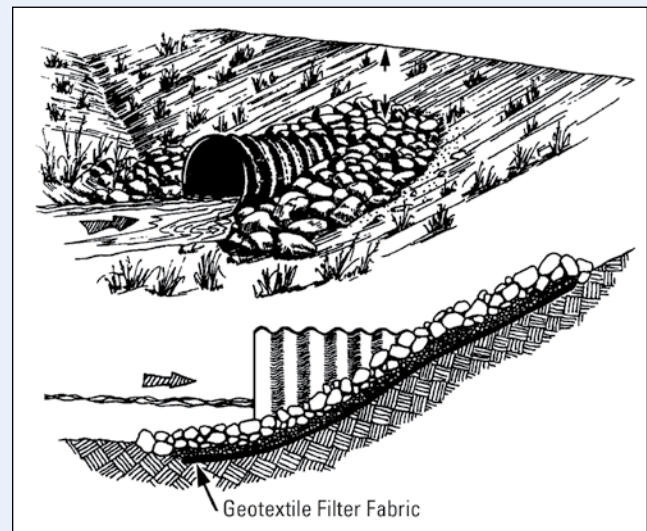


Figure 12-10: Use riprap around the inlet and outlet of culverts. (Figure Credit: WDNR)

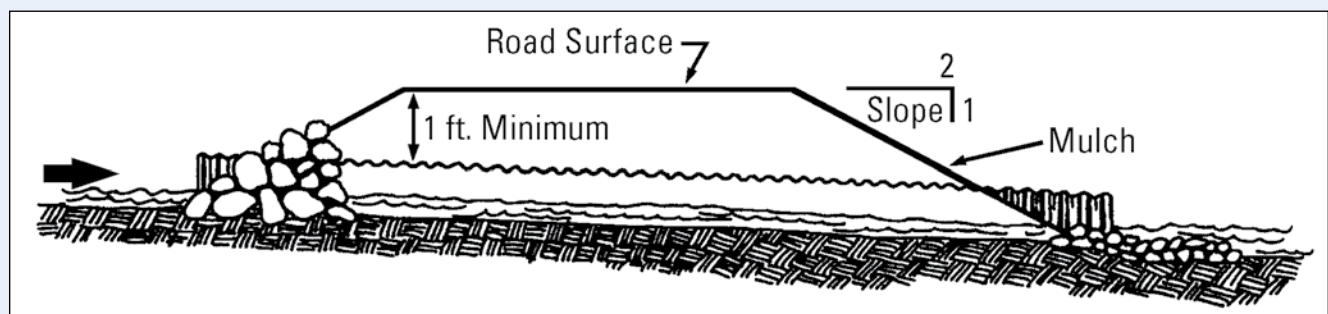


Figure 12-11: Install culverts so there is no change in the streambed elevation. (Figure Credit: WDNR)

BMPs: Fords

- ◆ Use fords for crossing dry streambeds or where fording would cause minimal water quality impacts.
- ◆ Locate fords where stream banks are low.
- ◆ Place fords in areas with a firm rock or gravel streambed. Install stabilizing material like reinforced concrete planks, crushed rock, riprap, or rubber mats on streambeds, if needed.



(WDNR, Carmen Wagner)

Figure 12-12: Fords are best suited to streams with a firm rock or gravel base.

BMPs: Temporary Stream Crossings



(WDNR, Shelly Wrzochalski)

Figure 12-13: This temporary bridge provides access for forest management activities when a permanent crossing is not needed.

- ◆ Use temporary stream crossings such as temporary bridges, timber mats, pole fords or frozen fords when appropriate.
 - Timber mats can span the width of smaller streams and are easy to install with a skidder or forwarder. Timber mats can be used in any season.
 - Pole fords may be used in small streams by placing poles (or small logs) side by side on the streambed. Pole fords must be removed immediately after use. Remove any debris before the upstream end becomes clogged and impedes stream flow.
 - Frozen fords are used in small streams when ice is thick enough or the streambed is frozen enough to protect the streambed.
- ◆ Anchor temporary structures on one end with a cable or other device so they do not float away during high water. Install them so they can be easily removed when no longer needed, regardless of season.

ROAD CONSTRUCTION AND DRAINAGE

The key to constructing forest roads is to get water off the road and then away from the road. The road construction BMPs focus on the first part – getting the water off of the road. This will not only help to prevent erosion, but will also ensure that a high quality road system is in place. There are three common road profiles – out-sloped, in-sloped and crowned. In general, the slope of any road surface should be

no more than two to six percent. More than that will make it difficult for vehicles to stay on the road in wet or icy conditions.

Road surfaces are normally crowned or sloped to remove surface water. Well-designed forest roads will change road profiles as needed, and have ditches and drainage structures to control runoff, prevent erosion, and ensure water quality.

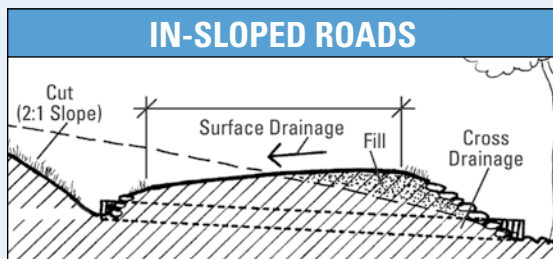


Figure 12-14: An In-sloped Road

(Figure Credit: Best Management Practices for Forestry: Protecting Maine's Water Quality)

Best Suited For:

- Single lane roads.
- Steep road grades (greater than 8%).
- Active roads.

Things to Keep in Mind:

- Ditches and drainage structures are needed to carry surface drainage away from the road.
- Regular maintenance of ditches and drainage structures is needed.

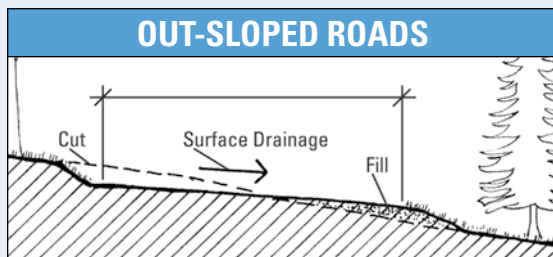


Figure 12-15: An Out-sloped Road

(Figure Credit: Best Management Practices for Forestry: Protecting Maine's Water Quality)

Best Suited For:

- Single lane roads.
- Flat or gentle road grades (8% or less).
- Seasonal and closed roads.
- Roads with light traffic.
- Situations where ditches or cut-slopes will be unstable and likely to erode.

Things to Keep in Mind:

- Surface should be kept smooth and rutting controlled.
- Vehicles can slide off in slippery or icy conditions.

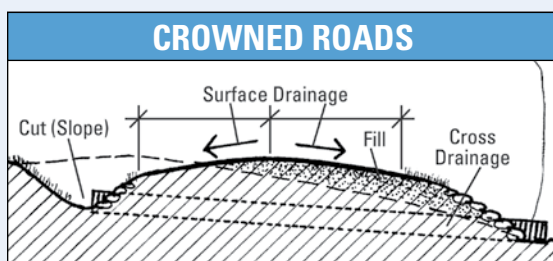


Figure 12-16: A Crowned Road

(Figure Credit: Best Management Practices for Forestry: Protecting Maine's Water Quality)

Best Suited For:

- Single and two lane roads.
- Flat or gentle road grades.
- Steep road grades if a single lane.

Things to Keep in Mind:

- Ditches and drainage structures are needed to carry surface drainage away from the road.
- Regular maintenance of ditches, crown and drainage structures is needed.

BMPs: Road Construction

- ◆ Design and construct roads to remove water from road surfaces to keep roads dry and structurally sound.
- ◆ Construct stable cut-and-fill slopes that will revegetate easily or stabilize these slopes with rock, seed and mulch or other methods to prevent erosion, if necessary.
- ◆ Do not bury debris in the road base. It causes uneven settling that can lead to erosion, frost-heaving, and mud holes.
- ◆ Compact the road base material or allow it to settle before using the road to reduce the amount of water that soaks into it. This will increase the road's carrying capacity, reduce road maintenance, and help to reduce erosion.
- ◆ Surface the road with gravel where steep slopes, erodible soils or high-traffic volume make the potential for surface erosion significant
- ◆ Locate gravel pits outside RMZs using proper location, development and soil stabilization practices to minimize erosion from the pits.
- ✍ 5.2 Avoid constructing new roads, skid trails, and landings in areas infested with invasive species where possible.
- ✍ 5.3 Avoid spreading seeds and other propagules from infested to non-infested areas during road maintenance, reconstruction, new construction, and closure.



(WDNR, Jeff Martin)

Figure 12-17: This waterbar, placed at the proper angle to the road, will intercept runoff water and direct it into the adjoining vegetation.

DRAINAGE STRUCTURES

BMPs: Drainage Structures *(continued on page 12-13)*

After the water is off of the road surface, you then need to get it away from the road. If water is confined to ditches along the roadside, two things will occur. First, the roadbed will become saturated and will not be able to support heavy traffic. Second, as water accumulates in the ditches and gains speed, soil can erode from the ditch, road bed and road surface. These problems can be avoided by diverting water out of the ditches and dispersing it into the adjacent forestland. This will not only help to prevent erosion, but will also ensure that a high quality road system is in place. Placement of drainage structures is often dictated by the landscape; however, care should be

taken to avoid directing runoff directly into lakes, streams, dry washes and wetlands.

Road drainage structures include cross drains and diversion ditches. Cross drains are designed to move water from a roadside ditch on one side of the road to the other and include pipe culverts, open-top culverts, rubber belt diverters, broad-based dips, and water bars. Diversion ditches direct water away from the road and disperse the water across the forest floor. Selection of structures will depend on road type, traffic volume and other considerations (see Table 12-1).

STRUCTURE	INFRASTRUCTURE				LEVEL OF TRAFFIC			TOPOGRAPHY	
	Permanent All-Season Roads	Permanent Seasonal Roads	Temporary Roads	Skid Trails	High Traffic Volume	Low Traffic Volume	No Vehicular Traffic	Rolling to Steep Slopes	Flat to Gentle Slopes
Cross-drain Culvert	✓	✓	✓		✓	✓		✓	✓
Open-top Culvert	✓	✓	✓			✓	✓	✓	✓
Rubber Belt Diverter	✓	✓	✓			✓	✓	✓	✓
Broad-based Dip	✓	✓	✓	✓	✓	✓	✓		✓
Waterbar			✓	✓			✓	✓	✓
Diversion Ditch	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 12-1: Recommended Uses for Different Drainage Structures

BMPs: Drainage Structures *(continued from page 12-12)*

- ◆ Install drainage structures to remove water from the road surface and ditches. Drainage structure should be installed immediately above steep grades, below bank seepages, and where water will flow onto log landings or forest roads. Space these structures at intervals close enough to minimize runoff volume and speed, avoiding ditch erosion. As road grades increase, use more drainage structures (see Table 12-2).
- ◆ Install a berm at the inlet of drainage structure, if needed, to direct water into the structure. Use rock riprap, mulch, and/or seeding at the inlet to prevent water from eroding and undercutting the structure.
- ◆ Provide erosion protection for outflows of drainage structures to minimize erosion and disperse the water, allowing it to soak into the ground. Rock riprap, mulch and/or seeding may be necessary.
- ◆ Install drainage structures at grades of at least two percent more than the ditch grade and at a 30° to 45° angle to the road.
- ◆ Check drainage structures to ensure that they are not filling with sediment or other debris. Clean if needed.
- ◆ Install cross drain culverts long enough to extend beyond the road fill. Size culvert cross drains according to the size of the road and the area drained by the ditch. To avoid clogging, culverts should be a minimum of 12 inches in diameter.
- ◆ Install cross drain culverts on a surface of compacted granular material. Firmly compact fill material around the culvert, particularly the bottom half. To prevent crushing, cover the top of the culvert with fill to a depth of one-third of the pipe diameter, or at least 12 inches (whichever is greater).
- ◆ Construct broad-based dips deep enough to provide adequate cross drainage and wide enough to allow trucks and equipment to pass safely. On high volume roads, place a surface of crushed rock stone or gravel in the dip and on the mound to prevent rutting from occurring. On low volume roads and where traffic can be limited during wet periods, a vegetated surface may suffice.

ROAD GRADE (PERCENT)	MAXIMUM DISTANCE BETWEEN WATERBARS (FEET)		MAXIMUM DISTANCE BETWEEN ALL OTHER DRAINAGE STRUCTURES (FEET)	
	High Erosion Risk (Most Sandy and Silt Soils)	Low Erosion Risk (Most Rocky and Clay Soils)	High Erosion Risk (Most Sandy and Silt Soils)	Low Erosion Risk (Most Rocky and Clay Soils)
0 to 3	175	250	250	350
4 to 6	125	200	175	250
7 to 9	100	175	125	175
10 to 12	75	150	75	125
13 to 15	60	100	60	100
16 to 20	50	75	50	75
21 to 30	40	65	40	65
30+	30	50	30	50

NOTE: Broad-based dips generally become ineffective on slopes greater than 10 percent.

Table 12-2: Recommended Maximum Distances Between Drainage Structures on Forest Roads and Skid Trails

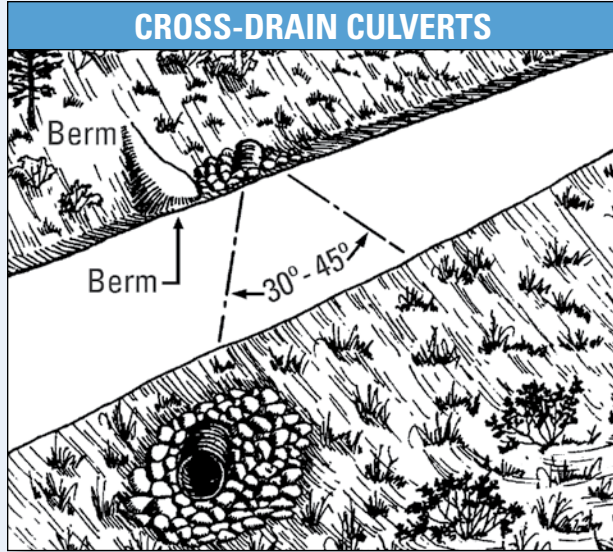


Figure 12-18: Cross-drain culvert. (Figure Credit: WDNR)

Best Suited For:

- Permanent roads.

Things to Keep in Mind:

- The road stays dry because water is diverted under the road.
- Cross drain culverts can be expensive to install, but allow faster traffic speeds.
- They can become plugged by sediment and other debris, requiring frequent maintenance visits.
- They can be used on temporary roads, but should be removed when the road is closed.

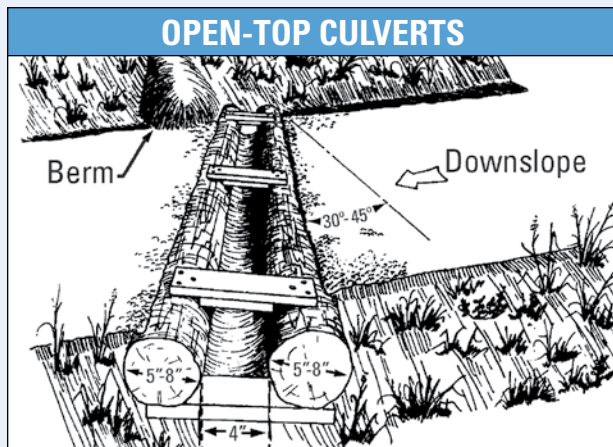


Figure 12-19: Open-top log culvert. (Figure Credit: WDNR)

Best Suited For:

- Low volume permanent and temporary roads.

Things to Keep in Mind:

- The road stays dry because water is diverted under the road.
- Open-top culverts are easy and inexpensive to install, but slow traffic speeds.
- They can be used on road with grades greater than 10%.
- They can become plugged by sediment and other debris, requiring frequent maintenance visits.
- Open-top culverts can be damaged by high volumes of traffic and heavy equipment.
- On temporary roads, they should be removed when the road is closed.

RUBBER BELT DIVERTERS

Best Suited For:

- Low volume permanent and temporary roads.

Things to Keep in Mind:

- They are easy and inexpensive to install, but slow traffic speeds.
- They can be used on steep roads without ditches.
- Rubber belt diverters can accumulate dirt, leaves and other debris and require cleaning.
- Rubber belt diverters can be damaged by high volumes of traffic and heavy equipment.
- Rubber belt diverters can be torn apart if logs are skidded over them.
- On temporary roads, they should be removed when the road is closed.

BROAD-BASED DIPS (GRADE DIPS)

Best Suited For:

- Permanent and temporary roads and skid trails.

Things to Keep in Mind:

- They can be used on active roads with or without ditches.
- They are most effective on roads grades less than 10%.
- Broad-based dips are difficult to construct on steeper roads.
- On high volume roads, gravel may be required on the road surface to prevent rutting. On low volume roads, a vegetated surface should suffice. Limiting traffic during wet periods will also help prevent deterioration of the road and drainage structure.
- Care is needed to ensure that the “dip” is not lost due to high traffic volumes and road grading.
- For high speeds and low clearance vehicles, the approaches should be longer and flatter. For low speeds and high clearance vehicles, the approaches can be shorter and deeper.

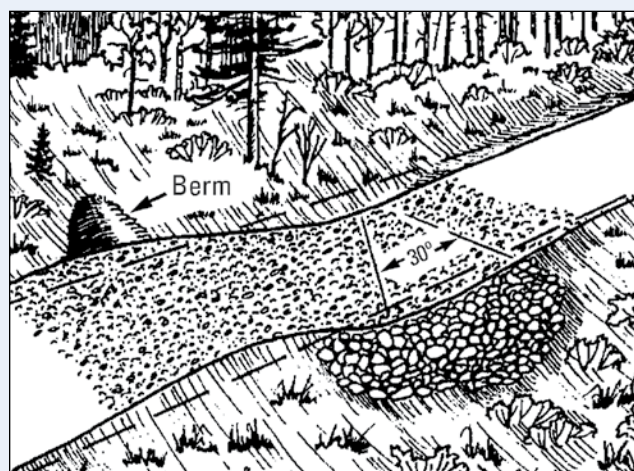
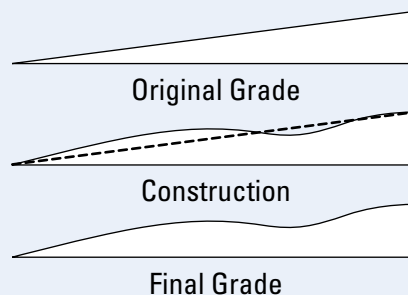


Figure 12-20: Broad-based dip (and cross-section).
(Figure Credit: WDNR)

WATERBARS

Best Suited For:

- Closed roads and skid trails.

Things to Keep in Mind:

- They are easy and inexpensive to install.
- They can be constructed with soil, logs and/or slash.
- They are not intended to be driven over.
- They require minimal maintenance.

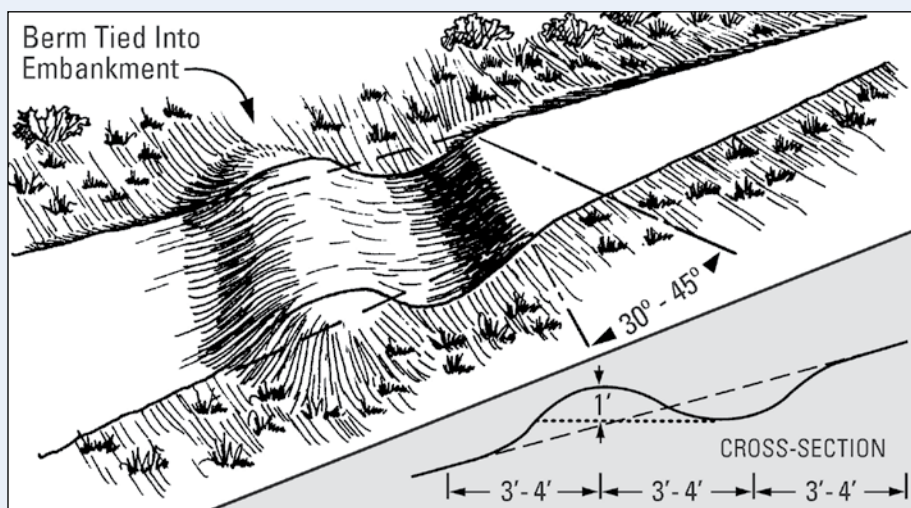


Figure 12-21: Waterbar (Figure Credit: WDNR)

SOIL STABILIZATION



(WDNR, Jeff Martin)

Figure 12-22: Once recommended as a wildlife planting, multiflora rose has become quite invasive in many locations.

Soil stabilization practices are used where soil is exposed, and natural revegetation is inadequate to prevent soil erosion (the detachment of soil) and subsequent sedimentation (the movement of soil). Soil can be exposed during road construction, by heavy volumes of traffic, and when closing out roads and skid trails. Some practices are designed to hold the soil in place and to prevent it from eroding, such as seeding and mulching, while other practices are intended to slow and capture sediment once it has begun to erode, such as straw bales and silt fences. There are a multitude of practices available to select from, depending on grade, slope length and location. These practices are often used in conjunction with one another to ensure water quality protection.

It is always more efficient and cost-effective to prevent erosion than to repair damage after the fact.

Timing is critical when implementing soil stabilization practices. Steps should be taken to stabilize any bare soils as soon as possible after it is disturbed. In the fall, seed may not germinate until the following spring, so soil stabilization practices in addition to seed and mulch may be needed to hold the soil in place during fall rains and spring snowmelt until the vegetation becomes established. During winter harvests,

temporary soil stabilization may need to be installed before spring break-up to prevent erosion and then permanent practices installed after the site has become dry enough for equipment to work on.

Soil stabilization is a critical aspect of limiting the introduction and spread of non-native invasive plants. Disturbed soil acts as a germination bed if invasive plants exist in the area or if soil is brought that contains invasive plant propagules. Seed mixtures should include fast-growing species for quick soil protection, plus perennial species for longer soil protection until native vegetation returns to the site. Do not use mixtures that contain aggressive or non-native invasive plants like reed canary grass, birds-foot trefoil, crown/hairy vetch, or tall fescue; use certified weed-free seed (see 6.1, 6.2, and 6.5). See the tables at the end of this chapter and the resources in Chapter 5 and Appendix H of the *Forestry BMPs for Invasive Species: A Field Manual for Foresters, Landowners and Loggers* for lists of seeds that should and should not be used.

After the site has become stabilized by vegetation, temporary stabilization practices, like silt fences, can be removed. It may be necessary to seed and mulch in areas that are disturbed by the removal of the temporary structures.

BMPs: Soil Stabilization

- ◆ Use seed, mulch, and/or erosion control netting where necessary to minimize soil erosion into lakes, streams and wetlands.
- ◆ Install sediment control structures where necessary to slow the flow of runoff and to trap sediment until vegetation is established at the sediment source.
- ◆ Maintain, clean or replace sediment control structures until areas of exposed soil are stabilized.

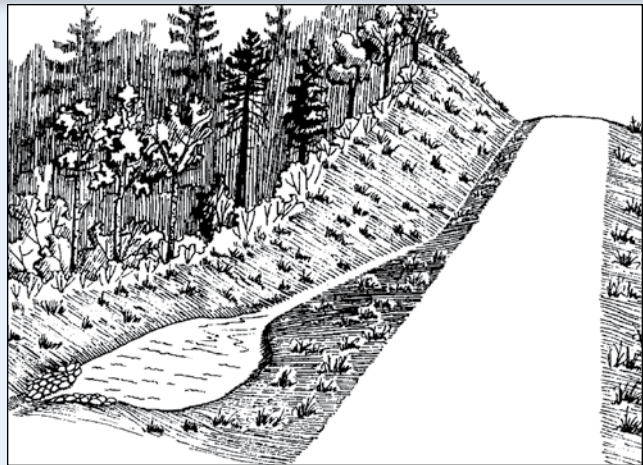


Figure 12-23: A sediment trap to slow runoff and trap sediment for channelized flow. (Figure Credit: WDNR)

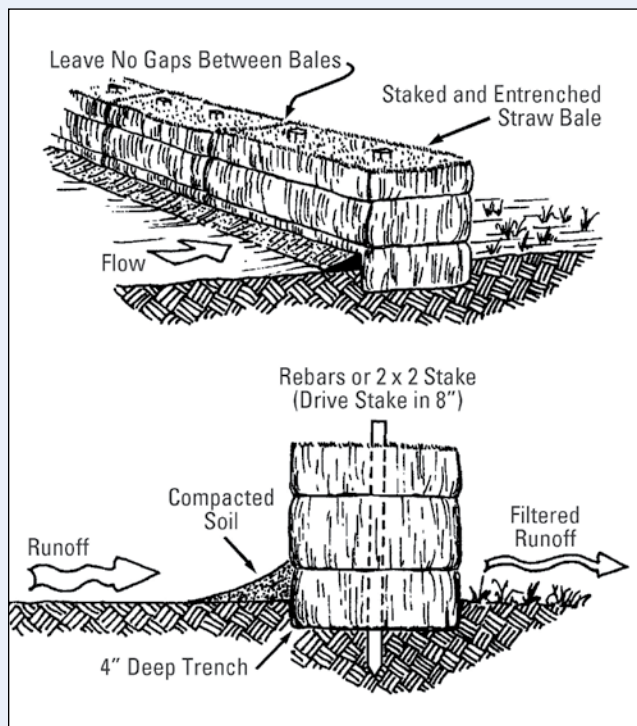


Figure 12-24: Straw bale fencing to slow runoff and trap sediment for sheet flow or channelized flow. (Figure Credit: WDNR)

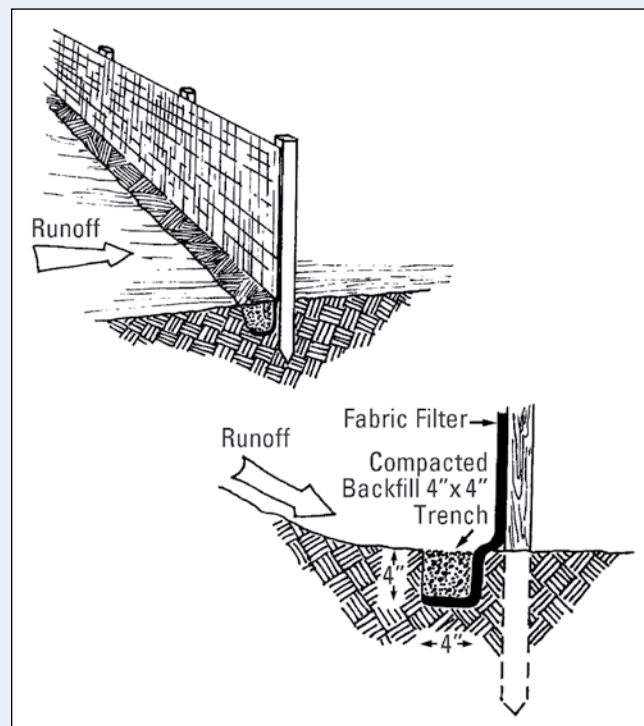


Figure 12-25: Silt fencing to slow runoff and trap sediment primarily for sheet flow, not channelized flow. (Figure Credit: WDNR)

WETLAND FOREST ROADS

BMPs: Wetland Roads, Skid Trails and Landings *(continued on page 12-19)*

Temporary roads, skid trails and landings in wetlands require firm or frozen ground. Any activities in wetlands must follow Wisconsin DNR and U.S. Army Corp. of Engineers regulations. Roads must be built carefully to avoid restricting the natural water flow of the wetland under the road.

- ◆ Construct upland road approaches to wetlands so the surface runoff is diverted away from the road approach and does not enter the wetland (see Drainage Structures, page 12-12).
- ◆ If landings are necessary in a wetland, build them to the minimum size required for the operation and to achieve the landowner's objective.
- ◆ Whenever practical, avoid locating roads and landings in the wetland filter; otherwise use extreme caution. The wetland filter strip begins at the edge of the wetland and extends a minimum of 15 feet away from the wetland.
- ◆ Avoid operating equipment in areas of open water, springs or seeps.
- ◆ Provide adequate cross-road drainage to minimize changes to natural surface and subsurface flow in the wetland.
 - For permanent roads with fill, use permeable fill material for at least the first layer of fill. Install culverts or bridges a maximum of 300 feet apart and at all natural drainageways. Install at least one cross-drainage structure at each wetland crossing.
 - For temporary roads, provide adequate cross-road drainage at all natural drainage ways. Temporary crossing structures include timber mats, culverts, bridges and porous organic material such as corduroy or chunkwood. Temporary crossings should be removed promptly when work is complete. If organic material is used, remove as much as feasible, given site and material conditions.

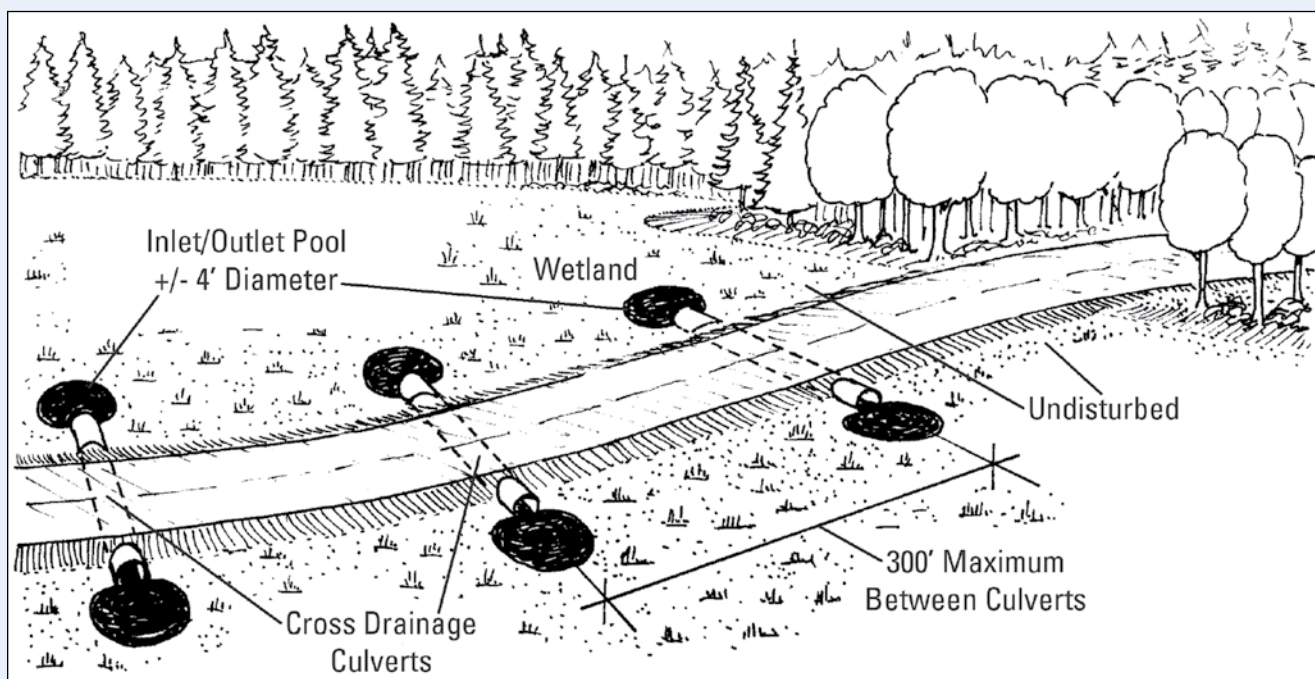


Figure 12-26: Cross-drainage structures should be no more than 300 feet apart in permanent wetland roads.
(Figure Credit: Best Management Practices for Forestry: Protecting Maine's Water Quality)

BMPs: Wetland Roads, Skid Trails and Landings *(continued from page 12-18)*

- ◆ Minimize rutting in wetlands by conducting forestry activities on firm or frozen ground that can support the equipment used. To achieve this:
 - Operate equipment on a day-to-day basis depending on weather conditions.
 - Consider using corduroy, slash, chunkwood or timber mats to improve the soil's ability to support traffic.
 - In the Winter:
 - To promote frost penetration, compact snow, grass, and brush.
 - Monitor air temperatures daily. As air temperatures rise above freezing, you may not be able to operate equipment beyond late morning without creating ruts. Soil frost begins to disappear when night temperatures stay above freezing for three or four consecutive nights.
 - In the Summer:
 - Operate equipment only when soils are dry enough to support equipment. Soils may become too wet after storms and extended wet spells.
- ◆ Cease equipment operations before rutting becomes excessive.
- ◆ Use low-ground pressure equipment, such as wide-tire or tracked equipment, if necessary to minimize rutting.
- ✍ 5.2 Avoid constructing new roads, skid trails, and landings in areas infested with invasive species where possible.
- ✍ 5.3 Avoid spreading seeds and other propagules from infested to non-infested areas during road maintenance, reconstruction, new construction, and closure.



(WDNR, Scott Fischer)

Figure 12-27: By using log corduroy at this timber harvest, the loggers were able to safely extend their operating season without damaging the wetland.

FEDERAL REQUIREMENTS FOR FOREST ROADS IN WETLANDS

The following 15 federal BMPs are required for the construction and maintenance of forest roads to qualify for the silvicultural exemption from a federal section 404 permit. The silvicultural exemption for forest roads is only applicable when the primary purpose of the road is for silviculture. This list is written in lay language. For the exact language of the law, contact the U.S. Army Corps of Engineers program manager in your area.

- Avoid filling wetlands if practicable alternatives exist – especially in breeding and nesting areas for migratory birds and spawning areas for fish.
- Limit the number, length and width of forest roads and skid trails to the minimum necessary to accomplish the forest management goals, consistent with topographic and climatic conditions.
- Locate roads outside of riparian management zones (RMZs), except at stream crossings.
- Place bridges or culverts in road fill to prevent constriction of expected flood flows – other design methods may also be appropriate.
- Stabilize fill to prevent erosion and sedimentation – before, during and after road construction.
- Minimize the use of equipment in wetlands outside of the fill areas.
- Minimize disturbance of wetland and aquatic vegetation during the design, construction and maintenance of roads.
- Design, construct and maintain wetland crossings to avoid disrupting movement of fish and other aquatic species.
- Use fill from upland sources whenever feasible.
- Place fill so as to not affect any threatened or endangered species and to prevent any adverse modification or destruction of critical habitat for these species.
- Do not place fill near public water supply intakes.
- Do not place fill in areas of concentrated shellfish production.
- Do not place fill in National Wild and Scenic River Systems – in Wisconsin, these are portions of the Namekagon, St. Croix and Wolf Rivers.
- Use fill that is clean, non-erodible and non-toxic.
- Remove all temporary fill and restore disturbed areas to their original elevation.

ROAD MAINTENANCE

BMPs: Road Maintenance

Roads must be well maintained. If not, erosion control and drainage structure may quickly degrade and endanger water quality. For both active and inactive roads, follow BMPs in Soil Stabilization, page 12-16.

ACTIVE ROADS

Active roads are generally open to vehicular traffic. Depending on the landowner and type of road, this may include logging trucks, light trucks, automobiles, tractors, light utility vehicles, and ATVs. A road may be closed seasonally or may be closed to other users, but still considered an “active” road.

- ◆ Inspect the road system at regular intervals, especially after heavy rainfall, to detect problems and schedule repairs.
- ◆ Clear debris from culverts, ditches, dips, and other drainage structures to prevent clogging that can lead to washouts. Place the debris where it cannot be washed back into these structures or into open water.
- ◆ Keep traffic to a minimum during wet periods and spring breakup to reduce maintenance needs.
- ◆ Shape road surfaces periodically to maintain proper surface drainage. Fill in ruts and holes with gravel or compacted fill as soon as possible to reduce erosion potential.
- ◆ Remove berms along the edge of the road if they will trap water on the road.
- ◆ When dust control agents are used, apply them in a manner that will keep these compounds from entering lakes, streams, wetlands and groundwater. Consult a qualified road engineer from the County Highway Commissioner’s Office or Wisconsin Department of Transportation for assistance in selecting the appropriate chemicals and amounts. NOTE: It is illegal to spread oil on roads, land or water in Wisconsin.

INACTIVE ROADS

When forest roads are inactive (not used by vehicular traffic) for extended periods, closing the system will help to protect the road surface and drainage structures. Consider erecting a barrier to traffic, such as a gate or berm, and post “closed” signs at the entrance of the road. If temporarily closed, state the length of time and/or reason for closure. Inviting acceptable uses may be helpful to assure compliance.

- ◆ Remove all temporary drainage and crossing structures.
- ◆ Shape all road system surfaces to maintain proper surface drainage, if necessary.
- ◆ Install waterbars where necessary (see page 12-15 and follow the recommendations in Table 12-1 on page 12-12).
- ◆ Inspect and maintain road surfaces, drainage structures, and crossings to minimize erosion.



(WDNR Archive)

Figure 12-28: Maintaining woods roads helps prevent erosion. This grader is shaping the road surface so that water runs off properly.

BMPs: Invasive Species

The following are Forestry BMPS for Invasive Species (IS-BMPs) that should be considered when constructing and maintaining forest roads.

- ☛ 4.3 Consider the likely response of invasive species or target species when prescribing activities that result in soil disturbance or increased sunlight.
- ☛ 4.4 Prior to moving equipment onto and off of an activity area, scrape or brush soil and debris from exterior surfaces, to the extent practical, to minimize the risk of transporting propagules.
- ☛ 5.1 To the extent practical, use existing roads, skid trails, and landings to reduce disturbance.
- ☛ 5.2 Avoid constructing new roads, skid trails, and landings in areas infested with invasive species where possible.
- ☛ 5.3 Avoid spreading seeds and other propagules from infested to non-infested areas during road maintenance, reconstruction, new construction, and closure.
- ☛ 5.4 Where site conditions permit, allow natural revegetation of the roads, skid trails, and landings to occur. If seeding or planting is necessary to minimize the threat of highly damaging invasive species from spreading, use native seed or non-invasive cover crops for revegetation.
- ☛ 5.5 Ensure, to the extent practical, that fill and gravel are free of invasive species and their propagules.
- ☛ 6.1 Limit the introduction and spread of invasives during reforestation or revegetation site preparation activities.
- ☛ 6.2 Revegetate or reforest as quickly as feasible after site disturbance.
- ☛ 6.5 Plan for post-planting management of invasive species.

INVASIVE SPECIES NOT RECOMMENDED FOR SEED MIXES

COMMON NAME.....	SCIENTIFIC NAME
Creeping Bent Grass.....	<i>Agrostis palustris</i>
Smooth Brome Grass.....	<i>Bromus inermis</i>
Crown Vetch.....	<i>Coronilla varia</i>
Quack Grass.....	<i>Elytrigia repens</i>
Tall Fescue.....	<i>Festuca arundinacea</i>
Flat Pea.....	<i>Lathyrus sylvestris</i>
Chinese Lespedeza.....	<i>Lespedeza cuneata</i>
Bird's Foot Trefoil.....	<i>Lotus corniculatus</i>
Big Leaf Lupine.....	<i>Lupinus polyphyllus</i>
Reed Canary Grass.....	<i>Phalaris arundinacea</i>

Table 12-3: These species were previously recommended for use in seed mixtures for revegetating bare soil but they have since been found to be invasive. These species should NOT be used in seed mixes.

NATIVE GRASS SPECIES RECOMMENDED FOR SEED MIXES

GRASS SPECIES		SITE CHARACTERISTICS					
Common Name	Scientific Name	Dry	Dry-Mesic	Mesic	Wet	Shady	Sunny
Big Bluestem	<i>Andropogon gerardii</i>	✓	✓	✓			✓
Fringed Brome	<i>Bromus ciliatus</i>			✓	✓	✓	
Kalm's Brome	<i>Bromus kalmii</i>		✓	✓			✓
Bluejoint Grass	<i>Calamagrostis canadensis</i>			✓	✓		✓
Broom Sedge	<i>Carex scoparia</i>			✓	✓	✓	
Fox Sedge	<i>Carex stipata</i>			✓	✓		✓
Tussock Sedge	<i>Carex stricta</i>			✓	✓	✓	✓
Brown Fox Sedge	<i>Carex vulpinoidea</i>			✓	✓		✓
Canada Wild Rye	<i>Elymus canadensis</i>		✓	✓	✓		✓
Bottlebrush Grass	<i>Elymus hystrix</i>	✓	✓	✓		✓	
Virginia Wild Rye	<i>Elymus virginicus</i>		✓	✓	✓		✓
Reed Manna Grass	<i>Glyceria grandis</i>			✓	✓		✓
Dudley's Rush	<i>Juncus dudleyi</i>			✓	✓	✓	
Common Rush	<i>Juncus effuses</i>				✓		✓
June Grass	<i>Koeleria macrantha</i>	✓	✓				✓
Switch Grass	<i>Panicum virgatum</i>	✓	✓	✓	✓		✓
Little Bluestem	<i>Schizachyrium scoparium</i>	✓	✓				✓
Dark Green Bulrush	<i>Scirpus strovirens</i>			✓	✓		✓
Wool Grass	<i>Scirpus cyperinus</i>			✓	✓		✓
Indian Grass	<i>Sorghastrum nutans</i>	✓	✓	✓			✓
Needle Grass	<i>Stipa spartea</i>	✓	✓			✓	✓

Table 12-4: These grass species are native to Wisconsin and could be considered in seeding mixes used to revegetate bare soils. More detailed information on plant species, seed mixes and seeding rates can be found in Wisconsin's Forestry Best Management Practices for Invasive Species: A Field Manual for Foresters, Landowners and Loggers, Appendix H: Species Recommended for Revegetation.

NON-NATIVE SPECIES RECOMMENDED FOR SEED MIXES

GRASS SPECIES		SITE CHARACTERISTICS					
Common Name	Scientific Name	Dry	Dry-Mesic	Mesic	Wet	Shady	Sunny
Oats	<i>Avena sativa</i>	✓	✓	✓			✓
Red Fescue	<i>Festuca rubra</i>		✓	✓			✓
Barley	<i>Hordeum vulgare</i>		✓	✓			✓
Alsike Clover	<i>Trifolium hybridum</i>		✓	✓			✓
Red Clover	<i>Trifolium pratense</i>		✓	✓	✓	✓	✓
White Clover	<i>Trifolium repens</i>		✓	✓		✓	✓

Table 12-5: These non-native species are suitable for cover crops and will provide short-term erosion control until other plant species become established. This is not a complete list.